## 34. EFFECT OF JAGGERY ON FISH LIFE[1]

The ecological conditions of South Indian temple tanks are favourable for fish-life. These religious institutional waters serve as sanctuaries where the fish population is protected and allowed to grow and breed[1,2]. Most of these waters contain a permanent bloom of a blue-green alga like *Microcystis aeruginosa* or *Anabaena flosaque* or *Oscillatoria tenuis*, and yield about 2,000 lb. of fish per acre per year, if suitably stocked with fishes like *Catla catla, Chanos chanos, Cirrhina mrigala, Cyprinus carpio* and species of *Labeo*[3]. But the immemorial religious custom of pilgrims dissolving jaggery as vow in these waters sometimes leads to heavy contamination and consequent large-scale mortality of fish.

### Fish Mortality in Nagasuni Tank

The Nagasuni tank of the Sankaranainar temple in Tirunelveli district has a waterspread of 2,450 sq. yards and an average depth of 10 ft. Its water was once baled out in 1945, and was found on examination in March 1946 to be favourable for fish culture (Table I). The tank was taken over by the Madras Fisheries Department in April 1948 and stocked with 500 fingerlings of *Labeo fimbriatus* and *Cirrhina reba* in November 1948 and with 840 *Etroplus suratensis* in the beginning of February 1949. The growth of these fish was satisfactory, the former two species attaining a size of 10 in. by the end of April 1949. The plankton of the water and the filamentous algal growth on the sides of the tank were rich and varied, and consisted of the following:—

*Myxophyceae.—Anabaena, Aphanocapsa, Microcystis, Oscillatoria* and *Spirulina*.

*Chlorophyceae.—Ankistrodesmus, Chaetophora, Closterium, Crucigenia, Euastrum, Gonatozygon, Oedogonium, Pandorina, Pediastrum, Selenastrum, Spirriogyra* and *Staurastrum*.

*Bacillarieae.—Mastogloia, Melosira, Nitzschia* and *Synedra*.

*Protozoa.—Chilomonas, Chlamydomonas, Euglena, Phacus* and *Epistylis*.

*Rotifera.—Brachionus, Diurella, Philodina* and *Salpina*.

*Copepoda.—Diaptomus* and *Mesocyclops*.

On 12th February 1949, about 100 fish were found floating dead in the tank; and thereafter 10 to 15 fish were found to die and float daily. Towards the end of February 1949, the water in the tank became black in colour and began to stink badly. By April, the colour of the surface water became dark green due to a thick bloom of *Microcystis aeruginosa*, but the bottom layer was almost colourless containing few specimens of the alga. The hydrological conditions

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[1] Communicated with the permission of the Director of Fisheries, Madras.

of the tank both at the surface and bottom at 11.45 a.m. on 28th April 1949 are given in Table I.

TABLE I

Showing hydrological conditions in the Nagasuni tank on 21-3-46 and 28-4-49.

| 21-3-1946 | | Conditions | 28-4-1949 | |
|---|---|---|---|---|
| 7-25 a.m. | 3-40 p.m. | | Surface | Bottom |
| Green | Green | Colour ... ... ... | Dark green | Colourless |
| 17·5 | 9·3 | Transparency, cm. ... ... | 5·0 | 30 |
| 27·2 | 32·0 | Temperature °C. ... ... | 33·8 | 27·9 |
| 7·1 | 8·9 | pH ... ... ... | 7·9 | 7·1 |
| 0·83 | 7·64 | Dissolved oxygen, cc/litre ... | 0·98 | nil |
| 0·56 | nil | Free $CO_2$, p.p. 100,000 ... | 0·234 | 0·796 |
| nil | 1·5 | Carbonates, p.p. 100,000 ... | nil | nil |
| 13·12 | 10·7 | Bicarbonates, p.p. 100,000 ... | 13·35 | 16·54 |
| 6·8 | 6·8 | Chlorides as Cl, p.p. 100,000 ... | 18·0 | 18·0 |
| — | — | Silicates as $SiO_2$, p.p. 100,000 ... | 0·77 | 0·83 |
| 0·006 | — | Phosphates as $P_2O_5$, p.p. 100,000 ... | 0·16 | 0·18 |
| — | — | $O_2$ absorbed in 30 minutes at 100 °C, p.p. 100,000 ... | 5·03 | 4·73 |
| nil | nil | Nitrates as N, p.p. 100,000 ... | nil | nil |

Abnormal or pathological conditions could not be noted in the dead fish. But from the above table it could be seen that the oxygen content of the surface sample was low and that the bottom sample was practically free of oxygen. The low oxygen content was due to the excessive rotting of the alga, which formed a coalesced slimy mass covering almost the entire water surface. There was a pronounced thermal stratification, as indicated by the high difference of 5.9°C. in temperature between the surface and bottom layers. Sulphuretted hydrogen was present in the bottom layer alone. But the water was frequently stirred from top to bottom by thousands of worshippers bathing in the tank; and this mixing of the hydrogen-sulphide containing bottom layer with the surface water would deplete the small amount of oxygen contained in the surface layer and thus bring about fish mortality. The formation of hydrogen-sulphide was due to the decomposition of excessive amount of organic matter under anaerobic conditions at the bottom. The excessive amount of organic matter is to be traced to heavy organic pollution and to throwing into the tank by the worshippers of large quantities of jaggery which is easily decomposed by the common saprophytic bacteria. Every last Friday in a month several devotees assemble to worship the deity and each of them throws into the tank approximately 0.3 lb. of salt and 1 lb. of jaggery. Further, during the Tamil months of *Thai* (January-February) and *Adi* (July-August) more than 50,000 people are reported to assemble in the temple and dissolve large amounts of jaggery in the tank.

*Laboratory experiments.*—The following are the results of a series of laboratory experiments conducted by us in 1950 to examine the effect of the addition of varying concentrations of jaggery upon fish life.

*Experiment I.*—Seven earthen pots, containing five litres of water in each, were taken; and in the first six were dissolved one-eighth, half, one, two, five and ten pounds respectively of jaggery so that the resulting solutions were of the strength 1, 5, 10, 20, 50 and 100 per cent jaggery. The seventh pot without any addition of jaggery was kept as control. All the pots were kept open and exposed to sunlight. Six fishes, one each of *Barbus stigma* (3″), *Danio aequipinnatus* (2½″), *Gambusia affinis* (1″), *Ambassis ranga* (1″), *Brachydanio rerio* (1″) and *Oryzias melastigma* (1″) were introduced into each of the pots. In 50% and 100% jaggery solutions all the fish were in distress immediately after release and floated dead in about 15 minutes; and in solutions of lower concentrations also they could not live as shown below.

| *Percentage of jaggery solution* | *No. of hours after which all fish died* |
|---|---|
| 100 | 0·25 |
| 50 | 0·25 |
| 20 | 21·0 |
| 10 | 45·0 |
| 5 | 45·0 |
| 1 | 192·0 |
| 0 | No death throughout. |

The physico-chemical variables of the solutions in the pots were examined at the beginning of the experiment soon after jaggery was dissolved and fishes were introduced, and are detailed in Table II.

TABLE II

Showing Results of Laboratory Experiment I

| | Pot 1 | Pot 2 | Pot 3 | Pot 4 | Pot 5 | Pot 6 | Pot 7 |
|---|---|---|---|---|---|---|---|
| Percentage strength of jaggery solution ... | 1·0 | 5·0 | 10·0 | 20·0 | 50·0 | 100·0 | Control |
| Temperature, °C ... | 32·0 | 32·0 | 32·0 | 32·0 | 31·4 | 31·0 | 32·0 |
| pH ... | 6·6 | 6·4 | 6·2 | 6·0 | 5·9 | 5·8 | 6·9 |
| Free $CO_2$, pp. 100,000 ... | 0·90 | 2·85 | 4·75 | 21·85 | 43·70 | 66·03 | 0·35 |
| Carbonates, pp. 100,000 ... | nil | nil | nil | nil | nil | nil | nil |
| Bicarbonates, pp. 100,000 ... | 22·26 | — | 68·02 | 102·04 | 241·2 | 466·9 | 15·77 |
| Dissolved oxygen, cc/1 ... | 1·82 | 0·49 | nil | nil | nil | nil | 4·75 |

From the table it would be seen that there was a slight reduction in temperature in the case of 50 and 100 per cent solutions; the pH decreased from 6.9 in the control to 5.8 in 100% solution (as the solutions were coloured dark brown, 1 cc. was diluted to 10 cc. with distilled water and the resultant pH alone measured using the indicators Bromo-thymol blue and Cresol red); free $CO_2$ and bicarbonates increased enormously with increase in jaggery; and dissolved oxygen content decreased from 4.75 cc./litre in the control to 1.82 cc./litre in 1% solution, to 0.49 cc./litre in 5% solution and to *nil* in all the other higher concentrations. Examination of the pots at the end of the experiment revealed that in all of them except the control there was no oxygen left and large amounts of $CO_2$ had accumulated.

*Experiment II.*—Experiments were conducted to find out the effect of varying concentrations of jaggery on *Microcystis*—containing tank water (*a*) soon after jaggery was added, (*b*) after 3 hours of exposure in sunlight and (*c*) after keeping for 3 hours in darkness, imitating natural conditions in a tank. Varying amounts of 50% jaggery were added to 500 cc. of tank water and the physico-chemical variables were determined under the above three conditions; and the results are detailed in Table III. There was a general decrease in pH and dissolved oxygen and an increase in free $CO_2$ and bicarbonates with increase in the amount of added jaggery. Pots exposed to sunlight were less affected by the addition of jaggery than those kept in darkness, in respect of pH free $CO_2$ and dissolved oxygen. It is evident from this experiment that the effect of the addition of jaggery will be greater at the bottom of tank than at the surface.

## Discussion

Jaggery is unrefined sugar produced from sugar-cane and is dissolved by the pilgrims in some temple tanks as a means of discharging their vows to God. Ordinarily when small amounts of the jaggery are added to these tanks, there is an increase in the general biota of the water and the fishes stocked in it are provided with more food. The Nagasuni tank at Sankaranainarkoil was rich in variety and bulk of fish food organisms and recorded good growth of fish. But when jaggery is added in large amounts as on festival days, there is an enormous increase of putrescible organic matter in the water which exerts a heavy oxygen demand. Taylor[4] found that the organic matter in freshwaters consist largely of plant residues in the form of particulate or, more commonly, soluble material, which is resistant to bacterial attack, but that the bacterial activity in lake waters responds to addition of glucose. It is quite probable that the added jaggery may stimulate the oxygen consumption by the rotting algae in the tank. As seen from laboratory experiment II, addition of large amounts of jaggery tends to create at the bottom of the tank anaerobic conditions which favour the decomposition of organic matter and the production of hydrogen sulphide. The latter may reduce the oxygen contained in the upper layers when the tank water is stirred by the pilgrims bathing in it. From the above considerations it will be evident that the addition of large amounts of jaggery is indirectly harmful to fish life and even cause their mortality on some occasions.

## TABLE III

Showing Results of Laboratory Experiment II

| Variables | Immediately after addition of jaggery solution | | | | | | After three hours of exposure to sunlight | | | | | | After three hours storage in darkness | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Amount of 50% jaggery added | 0 cc. | 1 cc. | 2 cc. | 5 cc. | 10 cc. | 20 cc. | 0 cc. | 1 cc. | 2 cc. | 5 cc. | 10 cc. | 20 cc. | 0 cc. | 1 cc. | 2 cc. | 5 cc. | 10 cc. | 20 cc. |
| Free $CO_2$ p.p. 100,000 ... | Nil. | 0·67 | 0·94 | 1·35 | 1·98 | 3·15 | Nil. | 0·49 | 0·54 | 1·17 | 1·80 | 2·88 | Nil. | 0·91 | 1·19 | 1·44 | 2·21 | 3·73 |
| Carbonates „ ... | 0·33 | Nil. | Nil. | Nil. | Nil. | Nil. | 0·66 | Nil. | Nil. | Nil. | Nil. | Nil. | 0·17 | Nil. | Nil. | Nil. | Nil. | Nil. |
| Bicarbonates ... ... | 40·96 | 45·29 | 48·0 | 50·62 | 50·62 | 61·94 | 40·63 | 41·3 | 42·62 | 46·60 | 31·95 | 58·61 | 42·5 | 44·0 | 46·6 | 50·62 | 54·0 | 61·3 |
| pH ... ... ... | 8·3 | 7·8 | 7·6 | 7·4 | 7·4 | 7·0 | 8·5 | 7·8 | 7·8 | 7·6 | 7·3 | 7·1 | 8·3 | 7·6 | 7·5 | 7·4 | 7·2 | 7·0 |
| Dissolved Oxygen cc/litre ... | 3·14 | 3·00 | 2·37 | 2·09 | 2·09 | 0·49 | 4·19 | 3·91 | 3·07 | 2·51 | 1·19 | 0·28 | 3·07 | 2·51 | 2·23 | 1·68 | 1·12 | 0·07 |

Laboratory experiments have also shown that one per cent concentration of jaggery is sufficient to kill young fishes in about 8 days, the addition of jaggery decreasing the dissolved oxygen and pH and increasing free $CO_2$ and bicarbonates of the water. Similar chemical effects produced by the cane sugar factory effluents from the Vuyyur factory and their harmfulness to the fish fauna of the Chandriya Kalva in Krishna district have also been noted by us[5,6]. Pytlik[7] has referred to the existence of a directly poisonous substance called *saponin* in sugar wastes. Laboratory experiments done by us proved that even 0.002 per cent solution of saponin will suffice to kill fishes like *Labeo fimbriatus* and *Barbus sarana*, 2 to 3 in. in size.

All these observations make it clear that the addition of jaggery to temple tanks is both directly and indirectly harmful to fish life. But it may be difficult to prevent pilgrims from dissolving jaggery in the tank, as such an act will interfere with religious sentiments. Therefore steps may be taken to harvest the fishery of the tank before the festival periods or not to utilise such waters for pisciculture.

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## 35. SPAWNING OF ROHU AT POWAI LAKE

I wonder whether anybody can throw light on the following observation:

Rohu spawned this year during the first heavy downpour period (after the Solar Eclipse) on 30th June. Fish taken on or before 2nd July were all full of roe. The lake level had then risen rapidly as 11 in. of rain had fallen within 48 hours.

On 4th July the level was 1 in. below the overflow. Three Rohu taken by me on that day were entirely empty; blood-red discolouration near the vent and orange spots on gill covers indicated that the fish had spawned. All fish taken thereafter had also finished spawning. Therefore breeding, whether successful or not, must have taken place between 2nd and 4th July. As usual fish immediately after the spawning were quite weak and did not put up a fight for about 10 days. Thereafter they have fully recovered and most of them did the typical Rohu leap, after being hooked.

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